

# Telegraph and Telephone



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1831.

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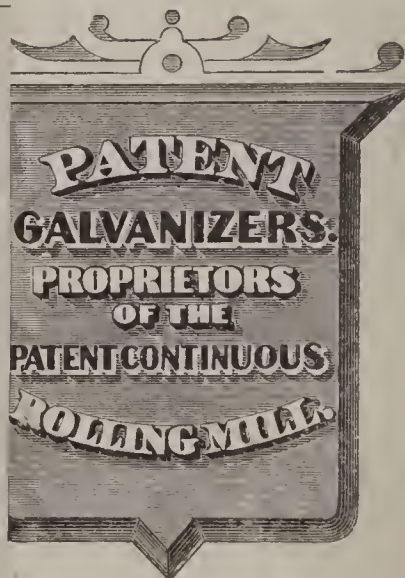
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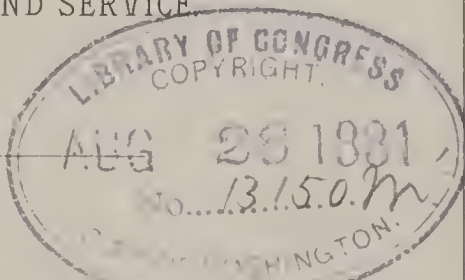
# GALVANIZED IRON WIRE

AS EMPLOYED IN THE

# Telegraph & Telephone



A HISTORY AND VIEW OF THE WORLD'S ELECTRIC  
ÆRIAL LAND SERVICE



WASHBURN AND MOEN MANUFACTURING CO.,

WORCESTER, MASS., U. S. A.

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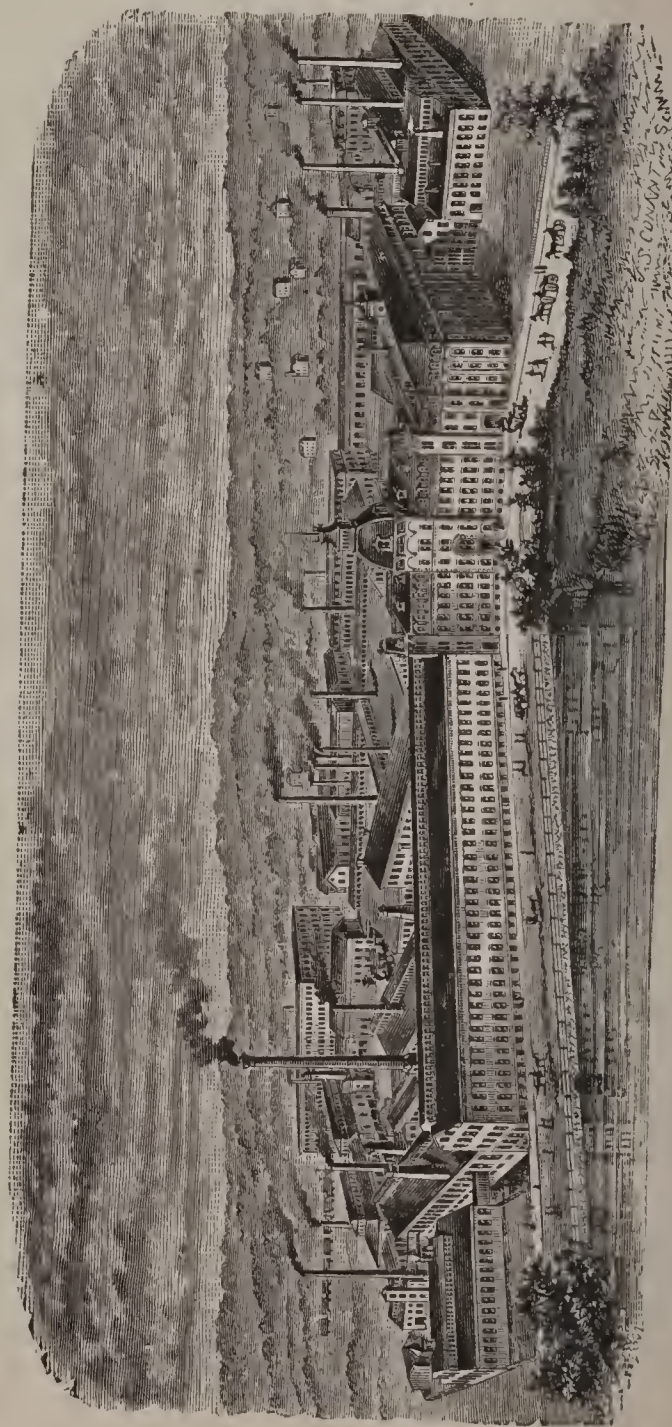
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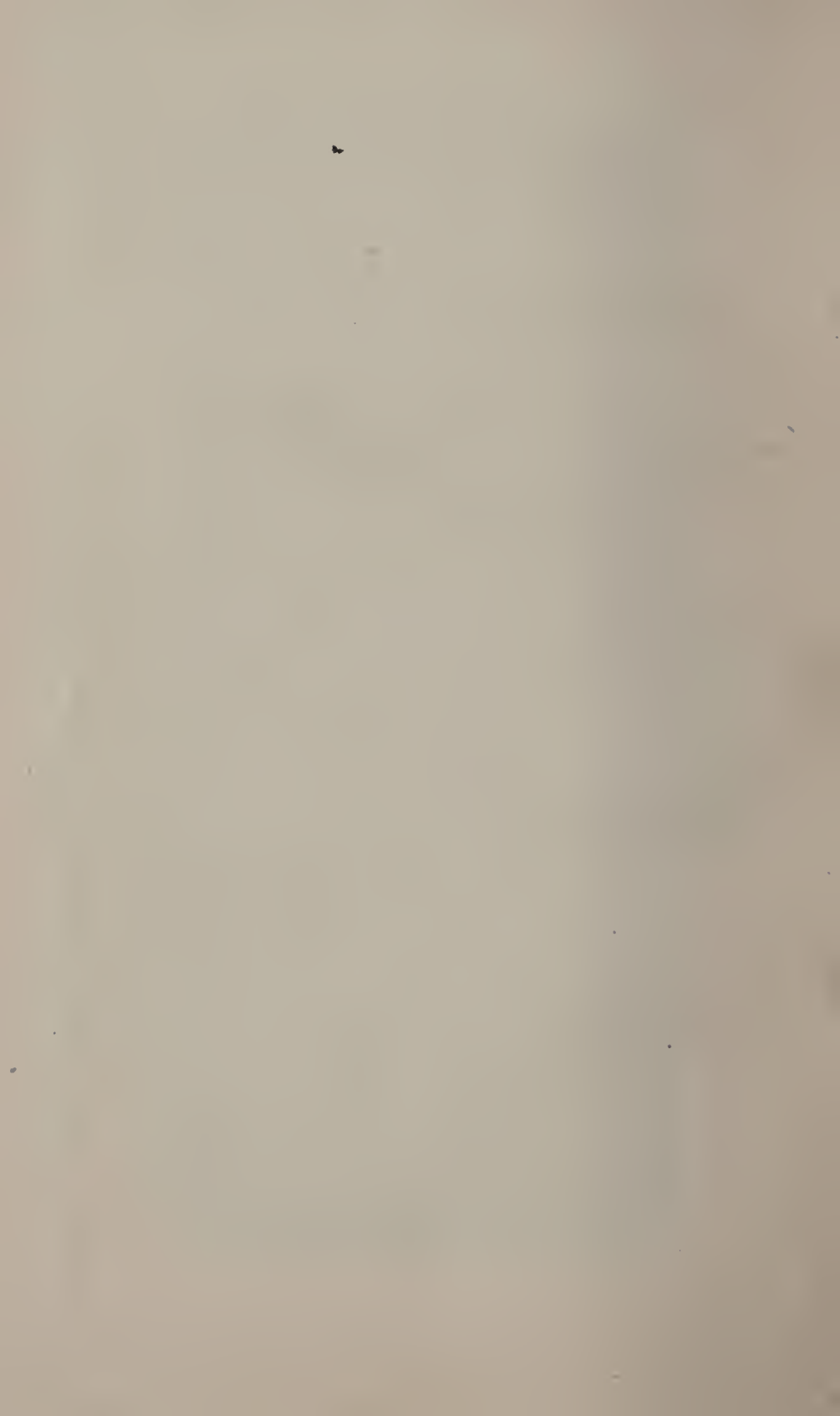


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# TELEGRAPH WIRE.

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Men of to-day, who are only beginning to confess to middle age, can recall the time not long ago when, in all countries, the relation of the professional Electrician to the business affairs of life, had the haziest of meanings. It is better understood in our own day, when the executive and operative armies of the Telegraph and Telephone number many thousands in all parts of the globe.

A careful review of the material facts of the world's Electric aerial land service, relating to the transmitting wire is attempted in what follows.

## HISTORY OF THE ELECTRIC TELEGRAPH.

In 1819, Professor Christian Ørsted, of Copenhagen, discovered Electro-magnetism, upon which the art of the Electric Telegraph is based.

In 1833, the Electric Telegraph was invented by Professor Weber and Counsellor Gauss, at Gottingen. The first land line of

telegraph was built by Professor Weber, in 1833, mainly for the purpose of experimenting, in an extended manner, upon the laws regulating the strength of currents under different circumstances. The line consisted of two wires, connecting the University of Gottingen with the Cabinet of Physics, and was about six thousand feet in length.

In 1836, William Fothergill Cooke, then a young Indian officer, completed a device for applying electric transmission to telegraphic purposes. He used six wires, forming three metallic circuits, influencing three needles, by which an alphabet of 26 signals was devised, practically the English Needle Telegraph, for many years in use in Great Britain.

In 1837, Messrs. Cooke & Wheatstone's Five-needle Telegraph was tried successfully on a small scale, by the London & Birmingham Railway company, near London.

In 1837, Professor Steinheil, of Munich, constructed a line of telegraph between the Royal Academy in Munich and the Observatory in Bogenhausen, a distance of three miles. Both wires were stretched from three to ten feet apart, over the steeples of the city. In places where there were no high buildings, the wires were attached to cross

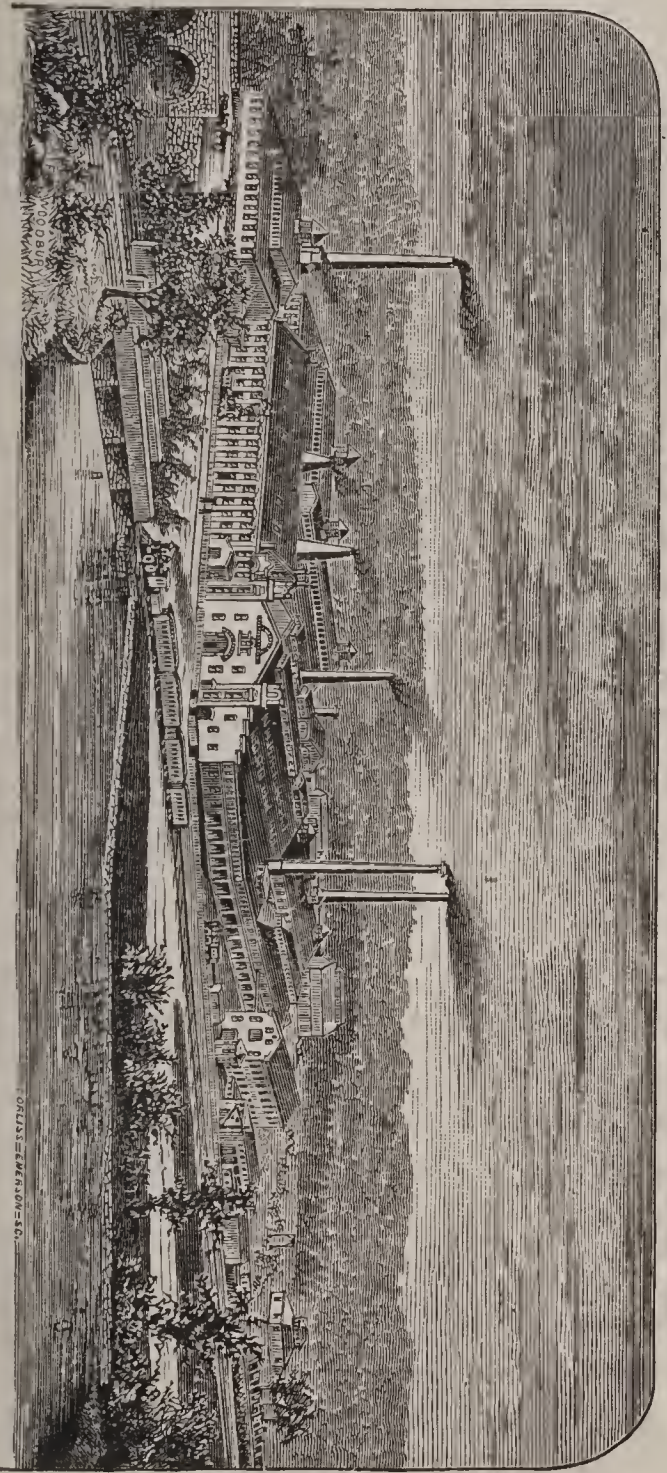
arms, supported by poles set in the ground. The poles were between forty and fifty feet in length, and the distance between them from six hundred to eight hundred feet. He had constructed two other lines, making three circuits of wire, but the whole were arranged to be on one common circuit. The three lines had double wires forming a complete metallic circuit. In experimenting with these lines, Prof. Steinheil discovered that the earth was a conducting medium in conjunction with the aerial wire; a discovery of great value in practical telegraphy, which has most largely contributed to the extensive development of telegraph service.

In 1839, the first working telegraph line was constructed in England, extending from Paddington (Great Western Railway), London, to West Drayton, a distance of a little more than thirteen miles. It was composed of six copper wires, enclosed in a wrought iron tube, an inch and a half in diameter, and six inches above the ground, which was laid alongside the railway. The wires were insulated from each other, within the tube by a covering of hemp. Its use was gradually but rapidly extended to the most important trunk lines. The primary object of these

first English telegraphs was the exchange of messages necessary for expediting the railway service; but it was soon found that the public would employ the telegraph if it were thrown open to them, and the railway companies, therefore, allowed their clerks to forward public messages, as a favor, upon payment of high rates. In this way, commercial telegraphy was grafted upon railway telegraphy, and both grew together.

In 1842, much difficulty having been experienced in the insulation of lines underground and in iron tubes, William Fothergill Cooke adopted the method of placing the wires on poles, and then of insulating them by attaching them to supports of stone or earthen-ware; and this method of aerial construction, with various modifications, has since been largely employed in all parts of the world, its greater cheapness largely stimulating the construction of telegraph lines.

In 1846, nine years after the first line had been put up in England, the first telegraph company—the Electric Telegraph Company—was incorporated. Its object was principally to erect lines for the railway companies and—so little was the public support reckoned



*Quinsigamond Works, Washburn & Moen Manufacturing Company, Worcester, Mass, U. S. A.*

WOODS  
(W. W. W.)

FORLISS & CO. N.Y.

on at the time—to transmit public messages in the spare time available.

In England no assistance whatever was rendered by the government, and it was only after several years of adversity that the undertaking became firmly established. On Feb. 1st, 1870, the English government entered into possession of all the commercial telegraph lines in the United Kingdom, for a total outlay of about \$40,000,000. The Electric Telegraph Company was at that time working 10,000 miles of line over 50,000 miles of wire. The railway companies retain their own service telegraph lines.

In June, 1840, Prof. S. F. B. Morse obtained his patent in the United States, based on the specification filed by him in April, 1838. He had devised a system of telegraphing in 1832, while on a sea voyage to Havre, and made some type for the model. In 1835-36, he exhibited it to his friends in New York. In 1837 he devised his system of combined circuits.

In 1843, March 3, Congress appropriated the sum of \$30,000 to aid Professor Morse in testing the practicability of his invention.

In 1844, Prof. Morse worked successfully the first telegraph line constructed in America,

forty miles long, between Washington and Baltimore. The earliest design of the inventor was to build an underground line, and forty miles of covered copper wire was ordered for the purpose, but when the first seven miles were laid, insulation failed, and this first telegraph line in the United States was built of No. 16 copper wire, carried on poles, and insulated at the points of support by means of cloth saturated with gum-lac. Prof. Morse's fame rests, in his own words, "*upon the invention of a new art, the art of imprinting characters at a distance for telegraphing purposes, all previous known modes of telegraphy being by evanescent signs.*"

In 1876 the problem of the electric transmission of speech was solved, in the Telephone, by Graham Bell and Elisha Gray, each working on distinct lines of inquiry, and reaching almost simultaneous results in investigations shared and variously claimed by numerous other parties on both sides of the Atlantic. The rapid introduction of the Telephone service stands without parallel in the history of inventions. In Great Britain the public Telephone service has been absorbed by the government as part of the Telegraph System.

The development of telegraphs in the United States was recently investigated with considerable care and pains, by a gentleman who has given the *Railroad Gazette* the following:

## U. S. TELEGRAPH WIRE.

Year.	—Miles of—		Year.	—Miles of—	
	Line.	Wire.		Line.	Wire
1848.	2,000	3,000	1866.	53,403	108,245
1850.	14,675	22,013	1870.	77,298	130,780
1853.	17,583	26,375	1877.	111,652	257,974
1860.	29,412	50,294	1880.	142,364	350,008

Thus, from 1860 to 1870, the period including the war, there was an increase of 162 per cent. in the length of line, and 220 per cent. in length of wires, and from 1870 to 1880 an increase of 84 per cent. in miles of line, and 119 per cent. in miles of wire, and in the three years from 1877 to 1880 the increase was no less than  $27\frac{1}{2}$  per cent. in line, and  $35\frac{1}{2}$  in wire, and this at a time when the country would seem to have been already pretty well supplied. There are now 350 people in this country to one mile of line and 143 to one mile of wire. By the same investigation, it appeared that at the end of 1880 there were about 14,000 telegraph offices in the country, and 24,000 employees, sending 50,000,000 messages yearly.

## THE WORLD'S TELEGRAPH SERVICE.

The following is a tabulated exhibit of the world's aerial telegraph service at the close of 1879; which we have caused to be compiled from official sources:

EUROPE.					
	Miles of Wire.	Miles of Line.		Miles of Wire.	Miles of Line.
Austria,	64,025	23,875	Netherlands,	7,708	2,890
Belgium,	16,430	4,733	Norway,	10,394	4,662
Denmark,	5,720	1,981	Portugal,	4,785	2,266
France,	96,410	35,960	Roumania,	4,470	2,589
Germany,	117,150	33,970	Russia,	117,203	58,970
Great Britain,	130,901	54,130	Spain,	20,620	8,563
Greece,	2,976	2,605	Sweden,	12,704	5,168
Hungary,	26,238	8,329	Switzerland,	5,508	4,332
Italy,	32,080	14,836	Turkey,	35,782	17,950
			Total,	711,114	281,809
NORTH AMERICA.					
British Provinces,	32,000	21,152	Mexico,	13,120	10,310
Central America,	1,150	810	United States,	299,859	130,580
			Total,	346,129	162,852

## SOUTH AMERICA.

	Miles of Wire.	Miles of Line.	Miles of Wire.	Miles of Line.
Argentine Republic,	12,029	5,530	Costa Rica,	200
Bolivia, . . .		608	Ecuador, . . .	210
Brazil, . . .		3,890	Guatemala,	1,320
Buenos Ayres,		4,000	Paraguay,	145
Chili, . . .		2,650	Peru, . . .	1,000
Columbia, . . .		1,838	Uruguay, . . .	1,466
			Total, . . .	22,857

## ASIA.

China, . . .	52	56	Java,	2,986
India, . . .	39,700	17,840	Persia,	5,546
Japan, . . .	7,000	4,838	Sumatra,	1,255
			Total, . . .	56,539
				29,267

## AFRICA.

Algeria, . . .	9,860	5,850	Egypt,	8,960
Cape of Good Hope,	4,150	3,380	Tunis,	650
			Total, . . .	23,620
				14,938

AUSTRALIA.			
	Miles of Wire.	Miles of Line.	Miles of Wire.
New South Wales,	11,760	7,078	2,403
New Zealand,	9,333	3,638	7,125
South Australia,	6,450	5,033	3,140
Tasmania,	1,018	910	
		Total,	41,229
			26,607

## RECAPITULATION.

	Miles of Wire.	Miles of Line.
Europe, .	711,114	281,809
North America,	346,129	162,852
South America,		22,857
Asia, .	56,539	29,267
Africa, .	23,620	14,938
Australasia,	41,229	26,607
Grand total, .	1,178,631	538,330

PROPORTION OF TELEGRAPH SUPPLY TO  
POPULATION IN 1879.

	Miles of Wire.	Stations.	Population.
Great Britain, . . .	154,901	5,375	32 000,000
France, . . . . .	107,218	4,132	36,102,921
German Empire, . .	98,750	5,455	42,756,910
Austria, . . . . .	60,190	6,198	71,818,970
Russia, . . . . .	62,296	2,516	87,722,000
Denmark, . . . . .	5,720	204	1,784,741
Norway, . . . . .	9,111	170	1,760,000
Sweden, . . . . .	12,704	522	4,250,412
Switzerland, . . . .	5,508	1,002	2,699,147
Netherlands, . . . .	5,830	330	3,674,402
Luxemburg, . . . . .	275	38	197,528
Belgium, . . . . .	16,430	586	5,283,821
Portugal, . . . . .	4,656	136	4,367,882
Spain, . . . . .	16,700	222	16,798,925
Italy, . . . . .	38,880	1,953	26,801,154
Greece, . . . . .	1,976	60	1,457,894
Turkey, . . . . .	30,400	444	9,791,582
Roumania, . . . . .	4,470	177	4,800,000
Servia, . . . . .	1,440	37	1,338,505
Dominion of Canada,	20,000	1,400	4,000,000
United States, . . .	245,662	8,500	40,000,000

It is impossible as yet to present accurate figures employed in the Telephone service, whose rapid extension in this country and abroad has been the marvel and almost the miracle of the past three seasons. It was authoritatively stated at the close of 1880 that there were upwards of 120,000 telephone terminals already established in the United States. The introduction of the Telephone

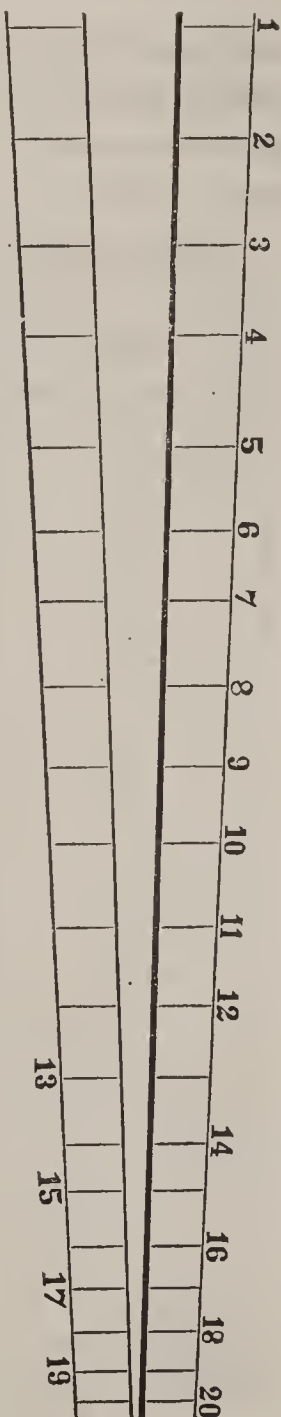
has become world-wide. It may be safely estimated that the present Telegraph and Telephone service together represent an aggregate of over ONE AND A HALF MILLION MILES of service wire, chiefly, for reasons hereafter to be shown, *Galvanized Iron Wire*, expressly designed for electric transmission.

#### SIZES OF WIRE IN USE.

Wire is known to the trade and in the references of electric science by the Gauge numbers adopted diversely by the wire manufacturers themselves. There are many wire gauges in use, and the subject of securing some universal and standard wire gauge has attracted much attention and discussion among the representatives of government standards, as well as scientific bodies, both in this country and Europe. It is known that the ordinary numbers of wire were in common use in 1735, and still earlier. These numbers were originally based on the actual series of drawn wires; No. 1 being the original rod and the succeeding numbers corresponding with each draw of the wire—No. 10 for instance having passed ten times through the draw plate. Each succeeding size in most of the standard gauges weighs

about 20 per cent less than the size preceding, this reduction having been established as the most convenient and suitable in practice when all wire was drawn by hand, as was the case when the pioneer enterprise of the Washburn & Moen Manufacturing Company was established in Worcester fifty years ago. Up to that time the workmen could draw out with hand pincers only fifteen pounds a day, and fifty pounds was a large day's work. The Draw Plate had been in use four centuries before the process of making wire was made simple and effective by the Drawing Block, *first introduced in this country in the Washburn Wire Mill at Worcester, Mass.* The present features of the wire gauges remain, however, mainly borrowed from that still earlier period.

We give a cut exactly reproducing the Washburn or Worcester Gauge, an adaptation of the old and long-known English Stubs Gauge. This gauge, and the old Birmingham gauge, represent by far the largest share of the Telegraph wire in use, and their numbers are constantly brought into references of tests and standards. For a more convenient showing of these two principal gauges, we give a cross section view of the



THE WASHBURN &amp; MOEN, OR WORCESTER GAUGE.

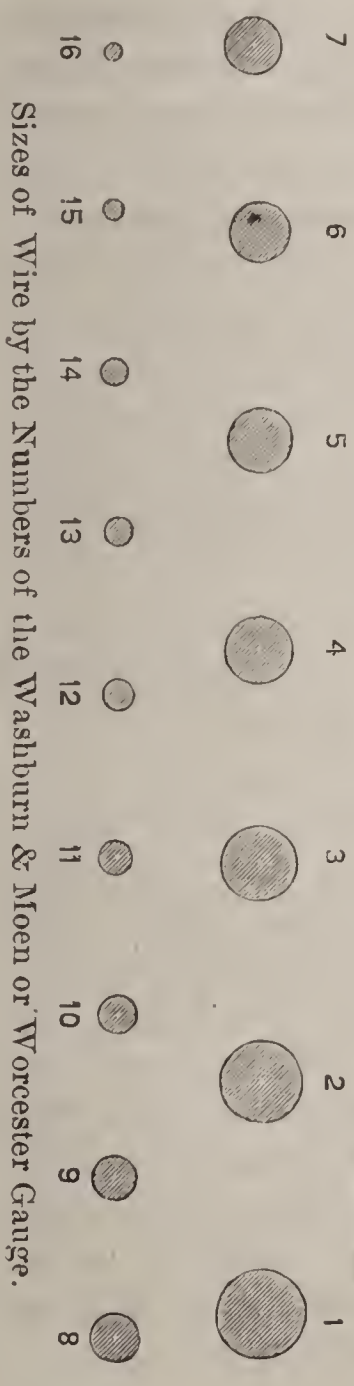
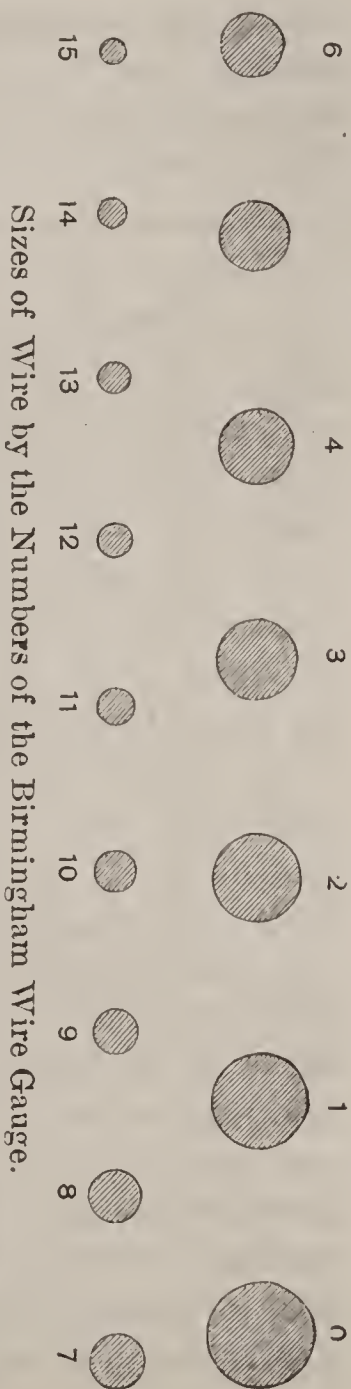
(*The Journal of the Franklin Institute* for 1878, Vol. 75, p. 103, contains a Report on a Standard Wire Gauge by a Committee of the American Institute of Mining Engineers, which discusses the various kinds of Gauges in use, viz.: 1. Those made with slots open at one end, intended to be parallel. 2. Those made with round holes in a plate; and 3, The fixed gauge, as shown above, consisting of a V cut into a plate of steel, or formed by placing two bars of steel together at one end, and leaving them open at the other, a fixed distance. The committee say of this latter form of Gauge, "The accuracy with which measurements can be made with this Gauge when it is new and well made, is surprising. Exceedingly minute differences even in the diameter of the same wires, can be detected and measured with great nicety.")

wire sizes in each gauge. These wires shown ranging from No. 1 to No. 16, comprise all the sizes known or required in the uses of electric service.

BIRMINGHAM AND WORCESTER GAUGES.

Gauge Numbers	Size in Mils. .001 in.		Weight per mile lbs.	
	B W. G.	W. G.	B. W. G.	W. G.
1	.300	.283	1210	1121
2	.280	.263	1054	968
3	.260	.244	909	833
4	.240	.225	775	707
5	.220	.207	651	599
6	.200	.192	538	514
7	.185	.177	461	439
8	.170	.162	389	367
9	.155	.148	323	306
10	.140	.135	264	255
11	.125	.120	211	202
12	.110	.105	163	154
13	.095	.092	124	118
14	.085	.080	97	89
15	.075	.072	76	72
16	.065	.063	57	55

It is becoming customary as a remedy for the confusion resulting from the varieties of gauges, to abandon gauge numbers altogether in all cases where close accuracy is required, and to express sizes of Telegraph Wire either by weight in a given length, or the measured diameter of wires expressed in thousandths of an inch, known as *mils.*



With this preface we are able to bring to the eye more clearly the various sizes of aerial telegraph wire employed in the world's service, which a reference to the preceding table and cuts will make readily intelligible.

#### THE WORLD'S TELEGRAPH WIRE.

No. 1 B. W. Gauge was employed in the earlier telegraph lines in India; believed to have been made necessary by the tendency of birds and monkeys to throng upon, and break down, the wires. It has, however, given place to lighter wires.

No. 3, B. W. G. has been employed in some instances in the most important circuits of the English Telegraph system.

No. 4 represents the largest size of Telegraph wire now commonly used, and as present finding increasing favor, for reasons to be later discussed in these pages. It has long been employed on the more important long circuits in England. It is in use in two wires of the great Asiatic line from Constantinople to Fas on the Persian Gulf. The very striking fact of the extensive adoption of No. 4 Galvanized Iron Telegraph Wire by the W. U. Telegraph Company in the United States, in the last two or three seasons, we comment upon in another place.

Nos. 5 AND 6 are employed for the International Circuits established between the capitols of Europe, by the International Telegraph Conferences. About three per cent of the telegraph wire used in the United States is No. 6.

No. 8 may be considered the medium size employed for aerial lines in Europe. It is employed on English lines for circuits not exceeding four hundred miles. In France, Prussia and Switzerland it is used for ordinary circuits. It is used solely on the Austrian lines. In the United States it has been largely used for more important circuits of the telegraph, but is giving way to No. 4.

No. 9 is used for less important circuits in most European countries; for the St. Gothard line in Switzerland; and solely for the entire Anglo-Persian system. In the United States nearly one-half of the telegraph wire used is No. 9, galvanized iron 320 pounds to the mile. It is also rarely used for more important Telephone lines, and District Police and Fire Alarm service.

No. 10 is used on English railway lines for short circuits, and it has a limited employment in the United States, in similar conditions; also being used for Telephone service.

No. 11 is used for 100 mile circuits on English telegraph lines; also in Belgium for branch lines out of the principal routes of travel; extensively on Swiss minor lines; in Prussia for leading-in wires crossing the railways; and for local and short lines in France. Not now much used in telegraph service in the United States, except for private lines, and Fire Alarm circuits. It is much used in the Telephone service.

No. 12. In England for short military lines of telegraph. In Germany for smaller branch routes. Little used for general telegraph purposes in the United States. Very largely employed in telephone circuits in the United States, and abroad.

Nos. 13. 14 and 16 are represented only to a limited amount in telegraph service in this country and abroad, except for short private lines, but the two former are largely employed in telephone service. No. 16, is largely employed for binding wire, at joints &c.

#### MATERIAL OF WIRE.

Without exception, the above references to wire in the telegraph service in this country and abroad, apply to Galvanized Iron Wire of the highest standards of excellence as indi-

cated in the following from the requisitions of the leading Telegraph companies.

*Old Electric Telegraph Company* (Great Britain). "Wire to be of iron highly annealed, very soft and pliable; not required to possess great tensile strength, but must be capable of elongating 18 per cent without breaking, after galvanizing."

*Belgian Requisition.* "Iron wire of first quality, even running, without flaws or faults; well galvanized."

*Prussian Requisition.* "To be subjected to 20 rectangular bends without breaking, and wound in a helical coil several times round a wire of its own size without split or break."

*French Requisition.* "Annealed charcoal wire capable of bending at right angles to itself in a vice first one way, and then the other four times without breaking, and must stand wrapping round itself."

*English Postal Telegraph.* "Highly annealed and very soft and pliable; free from scales, splits and inequalities. No deviation greater than .005 inch either way from prescribed diameter, well galvanized."

*Western Union Telegraph Company.* "Iron wire, to be soft and pliable, capable of bear-

ing at least 2.5 its weight in pounds per mile—well galvanized.”

### WHAT IS TELEGRAPH WIRE?

In the answer to this question it is our purpose to briefly present such facts and features as have grown out of the electrical research that has occupied for many years some of the brightest and keenest minds of our age; as well as those suggested by the experience and successful compliance with such demand, by the Washburn & Moen Manufacturing Company.

The earliest resort of the electrician and the practical telegrapher of the early day, was Copper wire, on account of its conductivity; No. 16 being generally used, the then condition of wire manufacture making that size most common. But the trial of Copper was short, and the verdict of abandonment universal. Copper wire when exposed in the long stretches demanded, becomes self drawn to a mere hair, or parts altogether from its own weight, and the inevitable vicissitude of line exposure.

“In selecting wire for telegraph purposes (says Preece) the points to be borne in mind are economy and durability, combined with low resistance to the passage of Electricity.

Iron is the material which most closely fills these conditions, and iron wire is consequently all but universally employed in open telegraph lines."

Jenkin declares that "wire suitable for the telegraph should be iron of great ductility, capable of being bent upon itself without injury; should be bent four times back and forth in a vise."

Sprague, whose treatise has universal authority, says "the iron should be soft and pure, since hardness increases the Electric resistance of metals. This shows that the transmission of Electricity depends upon molecular condition, for hardness is a state of stronger cohesion and rigidity, and therefore of less freedom of motion. Annealing diminishes this strain, and allows a readier motion of the molecules among themselves, and thus allows Electricity to pass more freely."

Douglas notes that the effect of wire-drawing is to harden the iron, and raise its tenacity from rather more than 24 tons, to an average of 37 tons per square inch, or nearly 50 per cent. The effect of annealing is to reduce the tenacity of the wire to that of the original bar. The iron used for Telegraph Wire

should be of good quality, commonly "Best, Best," with a high degree of ductility.

Dr. Matthiessen's elaborate tables are universally accepted as showing the lower resistance offered by pure metals, in comparison with impure or alloyed metals.

According to Culley "Iron containing a little carbon is stronger and twists better than pure iron, but has a higher resistance. Iron wire for telegraph use should be soft and capable of stretching 18 to 20 per cent before breaking. In very long spans, harder wire of greater tenacity may be necessary, but for general use the soft wire should be capable of being bent at right angles several times backward and forward without breaking, so that joints may be made securely. The breaking strain should not be lower for No. 8 than 1300 lbs, or four times its weight per mile."

Prescott declares that "Iron wire is now used for telegraph lines in all parts of the world, almost without exception, the best wire for telegraphic purposes being made from pure charcoal iron, which after having been drawn possesses a high degree of toughness, especially if annealed, and when broken discloses a fibrous structure."

## HOMOGENEOUS METAL.

Much wire used as iron, or put upon the market as such, especially since the introduction of the Bessemer processes for conversion of iron into low steel, contains more than 25 per cent, of carbon; it being the highest art of the wire drawer to work up to the stringent conditions of the specifications for best iron wire, above shown. This "homogeneous metal" is intermediate in composition between malleable iron and steel. All the tables show it to have greatly diminished conductivity. It supplies, however, a wire of great tenacity, and in the shorter lines of local service of the Telephone, (where it is asserted that a portion of the the high conductivity requisite in the Telegraph service, can be safely exchanged for tenacity in a wire of less cost and weight), it insures a very tough wire. But the call upon the manufacturer for a well made and well galvanized wire is no less stringent and exacting than in the former case, and, these features neglected, the intended saving becomes an actual waste to the buyer. The special features of the Telephone service remain to be discussed further on.

A series of recent elaborate tests at Manchester, England, were recently made upon different varieties of Iron wire, beginning with pure iron smelted, and worked throughout with charcoal, and ending with highly carbonized steel wires; the results showing that charcoal wire has the least electrical resistance, or about half that of piano steel, and it is noticeable that the resistance regularly increases as the impurities augment. Annealed steel, which comes about midway between pure charcoal iron and piano wire, in the amount of carbon it contains, is also intermediate in point of electrical resistance. Annealing considerably diminishes the electrical resistance of puddled iron wire. The breaking strain and resistance are also found to increase together in a fairly regulated manner. The heat conductivity of metals, it is curious to note, is nearly proportionate, as shown in these tests, to their electric conductivity.

#### TESTS OF TELEGRAPH WIRE.

The Iron wire manufactured exclusively for Telegraph service is known in the market in this country and abroad by terms common to the trade. "Best" is the ordinary puddled

wire and is in fact applied to almost any kind of telegraph wire.

“Best Best” indicates a superior quality to the former, and in its manufacture more expensive pig iron is used.

“Extra Best Best” is a higher quality obtained by the introduction of charcoal iron in connection with the last named.

This last is, almost exclusively employed, and it is the only description recognized in the elaborate tables of tests which form a valuable and indispensable feature of all discussions of Electric science applied to Telegraphy; though there are instances in line construction where long spans call for a wire of greater tenacity.

There are other important requisitions laid upon the expert wire-drawer by the uses of Telegraphy. These are divided into two classes: Electrical tests and Mechanical tests. That neither one of these can in its place be disregarded, will be easily understood from the fact that in the early use of Copper wire for line service, that material answered every electrical test, but proved mechanically insufficient. The well constructed line must in its conductivity transmit the current as perfectly as possible; and

not the less, for its permanence, must it possess sufficient strength to insure durability.

### ELECTRICAL TESTS.

This is not a treatise on Electricity, but rather a grouping of such known facts as establish the characteristics of wire; a brief review of the standards that have for many years given the reputation to the Telegraph Wire of the Washburn & Moen Manufacturing Company. The extension of the Electric Telegraph has made a practical knowledge of the terms and precise meaning of certain electric and magnetic phenomena necessary to, and a part of the ordinary business of a large number of persons who are more or less occupied in the construction and working of the lines, as well as interesting to many others who are unwilling to be ignorant of the use and meaning of the net work of wire that has come to bear such important and universal relation to the life and business of our communities. Until about 1850 measurements of Electrical Resistance, their purpose and meaning, were confined to the laboratory, but the extension of telegraph systems soon after that period, rapidly gave a practical value and notoriety to electrical

laws. Says Jenkin: "The first effect of the commercial use of resistance was to turn the 'feet' of the laboratory into 'miles' of telegraph wire." The early establishment of units of measurement began to find expressions at first different in different countries. Thus in England the mile of No. 16 copper wire; in Germany the German mile of No. 8 iron wire; in France the kilometre (3280 ft. 10 in.) of iron wire, 4 millimetres in diameter (No. 9). Previous to 1867 the unit of resistance employed in the United States was equal to that of one statute mile of No. 9 iron wire. By the nature and conditions of its utilities, the Telegraph at least in the domain of scientific research, has become international, and continually increasing evils resulted from the discrepancies invariably found in the results reported from these different standards, until in 1860 Dr. Siemens constructed his standard.

#### THE SIEMENS UNIT.

A column of chemically pure mercury 1 metre (39.37 in.) long, with a sectional area equal to 1 millimetre (0.0394 in.) square, maintained at the temperature of 0° centigrade.

In 1861 the British Association for the Advancement of Science appointed a Committee to determine the best universal standard of electrical resistance and as the result was adopted.

#### THE OHM OR B. A. UNIT.

This is stated by Culley as approximately equal in resistance to one mile of copper wire No.  $4\frac{1}{2}$  B. W. G. .2032 inch in diameter, and to between 7 and 8 feet of No. 35 B. W. G. .0085 inch diameter.

Prescott gives the Ohm as about equal to wire of pure copper, one twentieth of an inch in diameter, and two hundred and fifty feet in length; or of 330 feet of No. 9 iron wire, 155 inch diameter of average quality "Extra Best, Best."

According to Gordon a mile of pure copper wire No. 16 B. W. G. has a resistance of 13.7 Ohms.

Clark says the Ohm is equal to the resistance of a prism of pure mercury. 1 square millimetre section, and 1.0486 metres long at zero Centegrade.

The Ohm is equal to 1.0486 Siemen's units, and the ohm has been adopted in all English speaking countries, and is the recognized

standard in America. The Siemens Unit is in general use on the continent of Europe.

It is by the Ohm as a measure of resistance that the comparative values of telegraph wire are readily known to the telegrapher and in the market, where the Ohm has now as well recognized, though less understood, meaning than feet, pounds, or other expressions of measure. That these resistance unit measurements have a practical value on telegraphy, in its plainest business aspects, is assured in the fact that increased resistance in the line wire adds virtually to length of circuit, while increased conductivity admits of a reduction in battery power with a consequent decrease in the escape of electricity, and long circuits may be worked with much greater facility.

#### MECHANICAL REQUISITIONS.

It is noticeable that the requisitions of the telegraph companies establish very careful mechanical tests for iron wire, all science as well as experience having shown that electrical results will follow.

The wire must be tough and pliable, not merely to withstand strain, but because such structure and nature of the material, fully es-

tablishes the prime requisite of conductivity. The wire should be well drawn, without welds or splits, these being sure to betray their weakness under strain, besides insuring the rapid destruction of the wire by rust, and inevitably diminishing conductive power.

### LONG LENGTHS.

The wire should be in long lengths, to avoid joints; and the purpose of the long lengths is defeated if the occurrence of frequent faults makes it necessary afterward to cut and rejoin the pieces.

This leading indispensable feature of Telegraph and Telephone wire has long been the specialty of the Washburn & Moen Manufacturing Company's wire. OUR PATENT CONTINUOUS PROCESSES enabling us to draw wire from the rod into the longest lengths compatible with ease of handling in shipment, and line construction; this being the only limit.

### JOINTS.

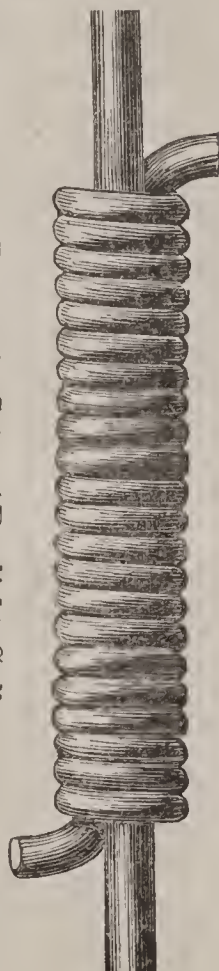
The science and experience of the practical telegrapher have long ago declared the cost and evil of joints. The best made joints are to be avoided in frequency as far as possible, as sure to increase the resistance of the line.



*Old Bell Hanger's Joint, (disused).*



*Modified Bell Hanger's Joint, (disused).*



*Britannia Joint, (English) Culley.*



*Common Twist Joint, (United States) Prescott.*



*Modified Twist Joint, (little used).*

A poor joint, rusty and unsoldered, will often cause more resistance than fifty miles of line. We illustrate a few of these joints known or in use in telegraphy, to show that quality of metal has primarily much to do with the perfect joint; a flawy and brittle wire cannot be made readily into a good joint, of the kind most common in line construction in this country. All joints require careful soldering.

#### MECHANICAL TESTS.

For telegraph service, certain tests for ductility are always specified, and these have secured the high reputation the Telegraph Wire of the Washburn & Moen Manufacturing Company has held in Telegraph Service, for many years. These tests may be classified as *Elongation* tests, *Torsion* tests, *Bending* tests. The nature of the last has been already sufficiently indicated. Severe tests of the quality of telegraph wire are inseparable from faithful line erection. The line-man who does his duty, will be sure to bring to light defects, unless this has already been done by the manufacturer.

But we are in this place to speak of the more formal and elaborate tests of the wire that stamp its character before it is

delivered for line use. The Elongation test consists in stretching a wire a certain percentage of its length, and its ultimate conclusion is reached in the breaking strain. In all cases short bars or wires stretch proportionately more than long ones. It is usual, therefore, to specify the length to be tested.

In general the elongation test is applied to pieces 10 inches long, and an elongation of 18 per cent. is commonly specified at this length; but Culley declares that ten feet is a more suitable length to exhibit the quality of wire.

Culley; in 75 tests of a wire 165 mils, (No. 9) found pieces 10 inches long stretched 19.5 per cent; pieces 120 inches long stretched 12.7 per cent; while in a few pieces tested in lengths of 100 yards the ultimate elongation was but little over 6 per cent. He also found that time occupied in testing the wire materially influences the results, the elongations being proportionately greater when the times were as 100, 173, and 311, the alternate elongations were 178, 154, and 138, respectively. Mr. Bell thinks this may be explained by the softening of the wire from the heat developed by rapid stretching.

Shaffner, in 1859, made and reported a series of tests of Galvanized Iron Telegraph Wire of Washburn & Moen manufacture, which is recorded in his Manual, (*p.* 521.) It is worth giving in this connection to show the high excellence our wire had already attained.

	Plain Iron Breaking Strain.	Zinc Coated Breaking Strain.
No. 6.	2.390	2.300
No. 7.	2.210	2.010
No. 8.	1.985	1.820
No. 9.	1.665	1.520
No. 10.	1.385	1.270
No. 11.	1.155	1.043
No. 12.	992	832
No. 13.	885	641

Good wire should begin to stretch with about half the breaking strain. We give an illustration of the effect of the breaking strain applied to a sample of Extra Best Best Galvanized Telegraph Wire No. 8, largely magnified to show the effect of the strain, both upon the Wire itself and the Zinc Coating.

#### THE TORSION TEST

is applied by holding a length of wire, generally six inches, in two vices a fixed distance apart, and causing the vices to revolve



Effect of Breaking Strain in No. 8 E. B. B. (Magnified.)



From Sample of 6 inches No. 8 Wire, E. B. B showing 19 Twists.

(The result of perfect Galvanizing is most strikingly shown in both these tests of the Washburn & Moen Manufacturing Company's Galvanized Iron Telegraph Wire. The strong union of the covering metal is exhibited in both instances.)

and twist the wire about its own axis. An ink line drawn on the wire previous to testing forms a plainly marked spiral, whose turns may be counted, and the ultimate number of turns is the test of ductility. The number of turns is inversely as the diameter of the wire. We give a cut of a sample of Washburn & Moen Manufacturing Company's E. B. B. galvanized No 8, that under this test showed 19 turns in 6 inches.

According to Culley, the better qualities of wire, charcoal and homogeneous metal bear the twist better than the elongation test. Thus comparing wire of a similar gauge :

	Ordinary Wire, 100 Mils.	Charcoal, 100 Mils.
Elongation, - -	17.4	17.
Twists in 6 inches,	12.	18.

	Ordinary Wire, 234 Mils.	Homogeneous 253 Mils.
Elongation, - -	17.6	17.6
Twists in 6 inches,	10.	13.

The number of twists that wire of the same quality will bear is inversely as its diameter. A wire of 253 mils, (No. 3,) bore 13 turns in 6 inches; a wire of 207 mils, (No. 6,) 15 turns; a wire of 146 mils, (No. 10,) 25 turns; a wire of 77 mils, (No. 15,)

38.7 turns; these being the averages given by Culley from a large number of trials.

To better illustrate the subject of tests, we copy from the *Journal of the Telegraph* a summary of the results of a series of mechanical and electrical tests recently made upon four samples of Galvanized Iron Wire, the sizes being those commonly used in telegraphic construction.

## MECHANICAL.

Pounds Weight per Mile.		Breaking Strain lbs.	Per cent Elongation
No. 9.	282.8	780 } 770	10
		760 }	
No. 9.	287.5	825 } 832.5	16
		840 }	
No. 9.	293.5	1260 } 1257.5	16
		1255 }	
No. 8.	378.1	1640 } 1635	10
		1630 }	

## ELECTRICAL.

Pounds Weight per Mile.		No. Twists in 6 Inches.	Percent conductivity (Pure copper 100)	Resistance per mile ohms 60 deg Fahr.
No. 9.	282.8	25 } 26.5	21.9	16.1
		28 }		
No. 9.	287.5	37 } 29	21.6	16.1
		31 }		
No. 9.	293.5	28 } 27.5	15.1	22.7
		27 }		
No. 8.	378.1	29 } 31	16.1	16.1
		33 }		

“The above results seem to point to one very interesting as well as important fact, viz: the close relation existing between the tensile strength and the electrical resistance of iron wire. It will be observed that the first three samples tested are of nearly the same gauge or weight per mile, the size being that usually designated as No. 9½. The tensile strength or breaking strain of the third sample is some 50 per cent. greater than that of the first two, while its specific electrical resistance is also comparatively very high. The proportionate tensile strength of the last two samples is very nearly equal, and so also is their proportionate conductivity, as compared with pure copper shown in the fourth column. There seems to be no apparent relation existing between the conductivity, or tensile strength of the several wires, and the percentage of elongation, or the number of twists that a given length will sustain before breaking. The high conductivity of the first two samples is very remarkable.”

#### GALVANIZED IRON WIRE.

We come now to speak of a feature of Telegraph Wire, inseparable from its permanent utility. Whatever the quality of the

original material, iron wire under nearly all exposures will certainly rust, and this tendency is increased by the passage of the current. All electric authorities have long been unanimous on the subject of the thorough and complete protection of the wire by Galvanizing. Dr. Lardner notes the difference wrought in the conductivity of plain iron wire when it has been coated with its own oxide, "it at times failing to transmit altogether through some unexplained atmospheric effect."

Prescott says, "Iron wire ought to be galvanized to prevent it from rusting as a matter of economy, to say nothing of the greater ease with which the current propagates itself upon it. Near the sea, wires not coated, rust off in a few years. In fact we have seen instances where they have completely melted away in less than two years under the influence of spray."

Culley declares, "It is perfectly useless to attempt to stay the progress of rust, after it has once commenced, for however carefully the wire may be cleaned the rust forms again. If a speck of rust is seen on the tubes of the Brittana Bridge, it is carefully chipped off with a cold chisel before it is re-painted."

Pope's Manual says, "Galvanized or zinc coated wire must always be used for permanent work, for rust reduces the conducting power of wire very rapidly."

Galvanizing adds to the wire surface on which the current is carried, an even better conducting medium than the iron; Zinc, according to the tables of M. Becquerel having a conductivity of 28.5, iron 15.5. All the best electric authorities agree as to the greater ease with which the electric current propagates itself on iron wire thus coated.

So early was the Galvanizing principle applied to telegraph wires, that the most durable portion of the telegraph lines has been the wire. "In no instance," says a competent authority, (*Engineer*), "has it been necessary to re-wire the oldest lines when not exposed to any especially destructive agency. In 1880 Mr. Preece tested before the London Society of Telegraph Engineers a sample of Galvanized Iron Telegraph Wire that had been in constant use on the London and South Western Railway for thirty-six years, and showed its unimpaired value. On the continent of Europe for a number of years, for motives of supposed economy, the use of Galvanized iron wire was extensively set

aside by several of the governments, notably Prussia, Austria, and Russia, the theory being held that at the same cost with Galvanized wire a larger wire of plain iron could be employed; but the system was abandoned after great loss. In 1877, Mr. Prescott, occupying a front rank among American practical electricians, elicited elaborate testimonials from the heads of the telegraph departments of leading foreign nations, some notes from which will be of value.

The Director General of Prussian lines, referring to the period of using plain wire above noted says, "Old lines constructed of plain No. 6 and No. 8 plain wire have suffered so considerably from rust as to necessitate their replacement, while the oldest lines of Galvanized iron wire are yet in a perfect state of preservation."

Rothan of the Swiss telegraph service confirms this same view. Neilson declares Galvanized iron alone to be in use in Norway, as the most permanently durable. Staring of Belgium says: "All our plain iron wires were replaced in 1872 when the diameter of such wires was found to have been reduced to one-half its original size from rust, and its electric resistance greatly impeded transmis-

sion, while our Galvanized wires have been in use for twenty-five years and their resistance has changed very little.

The Swedish telegraph service reports that "after a few years the non-galvanized wire became so deteriorated in consequence of oxydation that they have been replaced with Galvanized Wire." Vend, Director General of the Ottoman Telegraph, declares the use of plain wire not economical "as it can only be expected to last from 10 to 15 years." In Greece only Galvanized Wire has been from the first employed. The Italian telegraphs, to their confessed loss, made use of plain iron wire, which had to be taken down as unserviceable.

The official specifications of the French, Prussian, Belgian, and English telegraph systems now call for careful tests of Galvanized Iron Wire and will accept no other.

#### THE HISTORY OF GALVANIZING.

The utility of coating iron with Zinc by processes, very like those now in common use, was announced by Melouin in 1742, but the subject attracted very little attention until the discoveries and patents of M. Sorel at Paris, 1837, which were received with an enthusiasm that seems now remarkable. The

invention was patented in Great Britain by Capt. Crawford the same year with the French patents, and the subject attracted great attention from savans and all interested in the iron trade and its products. As a bit of history, and to show that galvanizing and not a simple coating was claimed by the inventor, we give an extract from Sorel's patent.

“To all whom it may concern, be it known that I, M. Sorel, of the city of Paris, in the kingdom of France, have invented or discovered a method, or methods, by which the various articles made of iron and steel may be effectually preserved from oxydation or rusting by the *galvanic action produced by zinc*. It is well known to chemists and to all persons versed in the physical sciences that a galvanic action is produced by the contact of two metals different in their natures, and that the most oxydable of the two metals thus brought into contact becomes positively electrified, while that which is least oxydable becomes negatively electrified, and also that when brought into this state the most oxydable or positively electrified metal has a tendency to become oxydized and will extract oxygen from compounds containing this agent, whilst the least oxydable of the two metals will be protected from oxydation although exposed to agents which would oxydize it but for the contact of the negative metal. \* \* \* The process of covering articles of iron with tin is well known and is exemplified most largely in the manufacture

of what is usually known under the name of sheet tin or tin plate, which consists of thin sheets of iron coated with tin. In this material there is necessarily galvanic action between the two metals, but it is to the disadvantage of that which it is proposed to protect, namely the iron, which being more oxydable than tin becomes positively electrified and has its tendency to rust increased, the sole protecting effect of the tin in this case depending upon the perfectness with which the iron is coated by it, as is clearly shown by the rusting of the iron whenever any portion of this coating is removed and the iron is exposed to the action of moisture. Were the galvanic action in favor of the iron it would be protected notwithstanding the abrasion of the tin, as its protecting influence is not limited to the mere point of contact, but extends far beyond it."

"In the scale of the oxydability of the different metals, commencing with those which are the most oxydable, it has been found that zinc stands before iron, and it follows therefore that when these two metals are brought into contact a protecting influence will be exerted upon the iron by the zinc, and that the rusting of the former metal will thereby be prevented."

"It might be supposed from the fact that zinc is more oxydable than iron, that this metal if set to protect iron would itself soon become oxydized or rusted, and would consequently leave the iron unprotected, and such reasoning would undoubtedly be just, but for another fact well known to chemists that there are certain metals, of which zinc is one, which after they have acquired their superficial coat of oxide are thereby effectually pro-

tected from the further absorption of oxygen under ordinary exposure.

He proceeds to specify his different modes of applying his invention under his patent. The Journal of the Franklin Institute of 1838 copies from the London *Mechanics Magazine* a large amount of testimony of eminent British chemists, sustaining the merits of the invention, under which influence the extension of the employment of the processes was carried out with great enthusiasm, and some of the assertions of these high authorities read strangely enough today. Thus Prof. Graham of the London University claimed that in experiments conducted at Dublin and Liverpool it was found that small pieces of zinc attached to each link of a chain cable were adequate to defend it from corrosion in sea water; and that so long as the zinc remained in contact with the iron links, the protection was observed to be complete, even in the upper portion of the upper chains by which buoys are moored, and which from being alternately exposed to sea water and air, are particularly liable to oxydation.

The experience of years has shown the futility of some of the extraordinary claims, but enough remains established to declare the value of a truth strongly urged by Sir

Humphrey Davy, and others after him, that in all cases where two different metals are in contact, a current of electricity will be established in them in such a direction as to protect the least oxydable of the metals. In common tin plate the corrosion of the iron is actually accelerated by the tin, at all points where the iron is exposed; a familiar fact.

Extensive discussion of this whole subject fills the scientific journals of the period, for years following the use of Galvanized iron. In 1844 the Journal of the Franklin Institute referring to the repeated failures of the principle, says, as remains true today, "These numerous failures have been produced by imperfect processes, the impurities existing in the zinc of commerce, as well as the rapid deterioration of the zinc in the act of applying it to the iron as ordinarily pursued."

This brief review will be interesting as establishing the scientific reasons why zinc has been chosen as the protector of iron; and its value in telegraph service has already been abundantly and triumphantly established.

As presented in the Patent Process of Galvanizing in use in their works, which has given the known high character to the Patent Galvanized Iron Telegraph Wire of the

Washburn & Moen Manufacturing Company, there is combined into one the three processes of Annealing, Cleaning and Galvanizing. The hard iron wire is first tempered by being passed through moderately heated tubes, then drawn through a bath of acid which removes all surface impurities, and thence carried directly through a bath of molten zinc. By this process under our exclusive patents in this country, an adhesion is secured between the two metals, the lack of which is often seen, and is a cause of loss in much imperfectly galvanized iron wire. The strong adhesion and actual incorporation of the zinc with our iron wire is strikingly shown in the illustration we have given of the Breaking test (see page 42) where, under the stress, the zinc follows the stretch of the iron as a part of itself. A still more striking proof is shown when a few inches of our galvanized wire is filed smooth, until to all appearances the last trace of zinc is removed. But when the twisting process is resorted to, a fresh appearance of zinc in minute particles is brought to the surface of the iron, showing that by our process of galvanizing the zinc in the contact of the two heated metals is actually taken into the substance of the iron.

We have thus given, as compactly as possible, the scientific facts and business reasons developed in practical telegraphy, why the Galvanized Iron Telegraph Wire of the Washburn & Moen Manufacturing Company still occupies, as it has done since the first introduction of the Telegraph, the front rank and foremost place in telegraph supply.

#### USE OF LARGE WIRE.

It remains to speak of a feature growing out of the higher development of the telegraph system, the use of large wire.

Much of the new, and all of the most important line construction of the Western Union Telegraph Company, in the past two or three seasons has called for No. 4 Wire in place of No. 8, and No. 9 as a marked tendency in advanced telegraph service.

There is nothing new in the discovery of the greater advantage of larger telegraph wire. In Shaffner's Telegraph Manual, before referred to, one of the earliest and most exhaustive treatises on operative Telegraphy (New York 1859), facts were urged to prove the great advantage of the use of the larger sized wire for telegraph lines.

Prescott declares: "The charge of electricity measured by its potential, resides

only on the surface of line wire, and its amount is determined by the magnitude and form of the surface. A No. 8 wire has a surface of 228.04 square feet to the miles; a No. 6 wire has 280.37 square feet."

Culley says: "The resistance lessens as the size of the wire increases, in the ratio of the square of its diameter."

Spon, "All other things being equal, the conductivity of wire is proportioned to its size."

Culley relates how an Admiralty Circuit of No. 8 wire between London and Devonport worked badly when insulation was imperfect, until, complaints having become frequent, a No. 4 wire was substituted, not better insulated than the other, when all trouble ceased. A No. 4 was for similar reasons, and with like results, substituted for No. 8 in the London and Leith line, which removed all difficulty in working.

From all the evidence of the best telegraph experts, the larger the wire the greater the strength of the signal that can be transmitted through it to any distance.

The less the size, and consequently the conductivity of the line wire, the more care is required in its insulation, for an increased

resistance virtually adds to the length of the circuit. Increased conductivity thus assured in careful choice and adaptation of a line wire gives great economy in battery power, and very long circuits may thus be worked with much greater facility; a fact which was too much ignored in the construction of the earlier lines of telegraph in this country.

Though all these electric facts have been long known, the impulse to the introduction of larger wire seems to have been resisted on the longer routes in this country, from supposed economic reasons, until the introduction of Multiplex Telegraphy enforced an increased working capacity of the wires.

The No. 4 Galvanized Iron Telegraph Wire of the Washburn & Moen Manufacturing Company is such a product as could only come from wire-drawing of highest experience, and from the best modern processes, many of them special to our establishment.

#### TELEPHONE WIRE.

It remains to refer to the latest and most marvellous development of electric transmission reached in the Telephone, which by its almost miraculously rapid extension has made a strong demand upon wire production

for the past three seasons. It is easy to see from the convenience already supplied to business and domestic life, why the telephone was forecast at the start for universal adoption. No reliable statistics are yet made public of the place the telephone has already occupied, but it has found adoption in all parts of the globe, both among the most enlightened, and even half barbaric nations. The Telephone supplies a feature in electric transmission the telegraph could never be expected to occupy, in the numerous short lines that have come to be centered in the Telephone Exchanges, found in all our large centres, and furnishing the sentient nerves of so many departments of our life and business. More than this the Telephone has already widely come into a use which displaces the Telegraph on routes where economy is served in doing away with the cost of operators, and supplying facilities, when these are realized in a perfection, that the best equipped telegraph office cannot supply. It is still a subject of inquiry to what ultimate distance the Telephone can be made practically available. It has been assured that conversation over a single wire can be carried on easily through two hundred miles of wire. It is

asserted recently that 800 miles distance have lately been conquered. It is believed that, by some yet to be realized perfection of appliances, the longest ocean cable will yet be employed for telephonic transmission.

#### WHAT IS THE TELEPHONE.

It is not the current alone that produces these results but the undulatory or constantly varying nature of that current. (*Spon*).

In the telephone the muscular effort of the speaker undergoes the following transformations :

1st, Into vibrations of the air.

2nd, Into metallic vibrations.

3d, Into magnetic waves.

4th, Into electric induction.

5th, Into magnetic induction.

6th, Into metallic vibrations.

7th, Into vibrations of the air.

8th, Into vibrations of the auditory apparatus.

The sounds that are heard in the Telephone are produced by the vibration of the metallic plate or diaphragm, which is set in motion by the vibration of magnetic intensity in the permanent magnet placed behind it, which variation of magnetic intensity is produced by a current of electricity traversing the coils,

thus itself constantly varying in intensity according to the motion of the diaphragm at the distant station.

According to one leading authority only about 1-1800 of the sound which is communicated to the telephone is transmitted to the receiver, but though so much weaker than the original vibrations, they so closely resemble them as to repeat the original quality of voice. The currents transmitted are so weak as to escape observation by the most delicate galvanometer as the magnetic needle however light must be too sluggish to be moved by such quick impulses. The rapidity with which these reversing currents follow each other, says Dr. Siemens, may be determined in transmitting the sound of a high pitched tuning fork, and from experiments in this direction Kontgen concludes that not less than twenty-seven thousand currents can be transmitted in one second.

#### WHAT IS TELEPHONE WIRE ?

In a field of inquiry and experience so new, there are yet widely diverse opinions as to essential facts, but the Telephone was born and rocked in the cradle of the Telegraph, as an heir to its general heritage.

Under most of the conditions in which the

Telephone is in use, on the short lines that make up the larger share of the service it is claimed as established that the light currents employed, and the small resistance offered by the shortness of the line, permit an economy of cost that warrants the exchange of some measure of conductivity, for strong light wires of greater tensility and hence more resistance. Brooks says; "it is found in Telephone working that the smaller the wire the freer it is from induction and the familiar noisy rattle." On the other hand it is claimed "that the volume of sound is increased by heavy wire. Thus in the telegraph wire No. 8, the sounds were fuller and stronger than in thinner wires, and faint sounds were more readily transmitted." (*Engineering.*)

Without the purpose to enter into the discussions of electric science now engaging some of the greatest and most earnest minds of the age, the Wire Manufacturer can at least properly consider these established facts thus far developed.

1st. For longer lines, for distances to the utmost limit of length yet attempted for regular telephonic communication, the larger share, and almost the whole of the best and most successful Telephone service is now

carried on over lines constructed of from No. 10 to No. 11, No. 12 and No. 14 (with a preponderance toward the last two sizes,) of high grade, Galvanized Iron Telegraph Wire selected by exactly the same specifications and tests as for Telegraph service. Some notable instances are afforded of the failure of long telephone lines built with cheap wire of low conductivity. The best and most successful longer Telephone routes, and some of the best Telephone Exchange systems in the eastern as well as the western states have been built with "*Extra Best Best*" Galvanized Iron Telegraph Wire of the Washburn & Moen Manufacturing Company.

2nd. For local and district short lines, a cheaper, strong, tough wire of homogenous metal is employed it is declared, with perfectly successful working; from 3 to 4 ohms per mile being exchanged it is believed, safely and with profit, when cost is considered.

But whatever wire be used for the Telephone, so far as conductivity is concerned, there can be no safety nor economy in the departure from the fact that, be the material what it may, the wire should be *well made*. Since the large adoption of the low steels for many of the uses for which iron was not long

ago solely employed, it has proved very easy for some manufacturers with cheap appliances, to flood the market with poor and faulty wire with a flimsy pretence of Galvanizing. The qualities of all good wire depend not less upon the drawing than upon the material, whatever the grade demanded. The protection of all Iron or Steel Wire depends on perfect Galvanizing. The Patent Galvanized wire of the Washburn & Moen Manufacturing Company has the same excellence and faithfulness in all grades, and the benefits of our fifty years experience in Wire Production.

1831 — 1881

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## Fifty Years of Wire Manufacture.

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The Wire Product of the United States is about *one hundred and twenty thousand tons* annually, of which about one-third, or from 36,000 to 40,000 tons represents the annual product of the **WASHBURN & MOEN MANUFACTURING COMPANY** at the Grove Street Works and Quinsigamond Works at Worcester, Mass., cuts of which are given in these pages. The area occupied by this company is a total of twenty-three acres, with structures of the best type of their class, the exterior features of which, with their general arrangement, will be best understood from the engravings. The Grove Street Works present a continuous front of 600 feet of solid brick structure, to which the principal central building, in which are the Company's General Offices, gives an excellent effect, with its massive proportions and shapely tower. It was on this site that the first Washburn Wire Mill was established to employ the power of Mill brook, whose waters still feed the adjoining Salisbury pond.

The history of Washburn & Moen Manufacturing Company runs back to 1831, the present year being its **SEMI-CENTENNIAL**.

This company now employ about 2600 men; many of them for years in its service. An aggregate of 3000-

horse power represents the motors that drive the machinery of these works. The floor space represents a total area of something over twelve acres.

These may be taken as the essential facts of this establishment, now and for years past the *largest exclusive Wire Drawing establishment in the world.*

The history of the WASHBURN & MOEN MANUFACTURING COMPANY both in time, and in its connection with some of the most essential features of its progress, represents in this country almost the entire period of the history of WIRE DRAWING in its broadest relation to our industries. Though wire making was one of the earliest of the arts in the treatment of metals, it is not until within the past half century that improved processes in the treatment of the commonest metals made wire an almost universal utility.

At the present time this Company are making NINETY-FIVE different kinds of Wire. While Patent Galvanized Iron Telegraph and Telephone Wire, and Patent Galvanized Steel Fence Wire stand as leading specialties, its wire product contributes to upwards of FORTY different lines of leading manufacture.

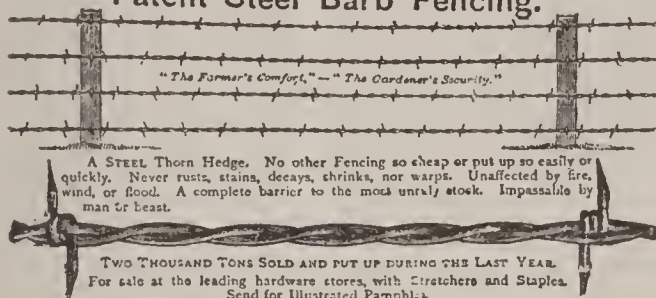
For the whole period since the first practical Telegraph lines were established in this country, the Galvanized Iron Telegraph Wire of this company has been recognized as the standard in excellence, and these works have been the leading source of supply of the best Telegraph Wire in use.





WASHBURN & MOEN M'F'G CO.  
Worcester, Mass.

Patent Steel Barb Fencing.



125,000 MILES IN USE SINCE 1876.

Send for Circulars and copies of "THE FARM."

